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Effect of land use change on ecosystem services in Lake Balaton Catchment

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ABSTRACT

Land Use and Land Cover Changes (LULCC) are interrelated with other global processes like global climate change, population growth, land degradation *etc.* Land use structure of a given area, region is adapted to the requirements of human society since the appearance of human beings. Land use structure is understood as the proportion of land use types orruring in a given area. The objective of the paper is to analyse land use changes in Lake Balaton catchment, Hungary and to present the role of changes of one ecosystem service, *i.e.* recreation and tourism by quantitative methods, based on spatial and statistical databases of land use and tourism in Lake Balaton catchment, Hungary between 1990 and 2012. The study area is a frequented touristic region of Hungary with variegated and beautiful landscape mosaics. The lake (595 km^2) is exposed to various kinds of environmental impacts including agricultural activities and tourism. For the quantification of the Recreation and Ecotourism Ecosystem Service potential the Multi-Criteria Evaluation (MCE) method was applied.

Land use changes between 1990 and 2012 were identified from the CORINE Land Cover Database and evaluated from ecological aspects and from the aspect of ecosystem services. The main changes include a continuous increase of the forest area and a remarkable on-going decrease of arable land. Soil erosion as the main land degradation process in the area endangering the quality of ecosystem services. The remarkable decrease of arable fields reduces erosion risk. Ecosystem services provided by each land use type were analysed. The main conclusion is that long term trend of land use changes is beneficial for ecosystem services.

1. Introduction

Land use structure of a given area, region is adapted to the requirements of human society since the appearance of human beings, but of course, land use structure has become really important since the industrial revolution and the changes of land use structure can be considered as a very significant global process in the recent past. Land use today can be interpreted as a human intervention into the landscape.

Land Use and Land Cover Changes (LULCC) are interrelated with other global processes like global climate change, population growth, land degradation etc. The relationship between climate change and land use change is very significant. Foley et al. (2005) draw our attention to this: since 1850, roughly 35% of anthropogenic CO_2 emissions resulted directly from land use. World population is growing very rapidly, with different rates in different parts of the world and it is well known that an increasing demand for space and food require changes of land use structure (Szabó et al., 2016). It is evident that land cover change, *e.g.* deforestation may lead to land degradation and to severe damages on the Globe. Another important global process is the extension of urban and industrial areas. Urban intensification is accompanied by large increases in resource consumption, habitat fragmentation and biodiversity loss (Foley et al., 2005; Lawler et al., 2014).

The effect of land use change on ecosystem services is very important in Sub-Saharan Africa (SSA) which is one of those regions of the world where land use change can lead to important land degradation and desertification processes. Besides deforestation, conversion of grassland to cropland are the major factors of LULCC (Nkonya et al., 2016) in SSA.

LULCC have a great impact on the status and integrity of ecosystems and their capacity to supply ecosystem services (Quintas-Soriano et al., 2016). In these investigations the spatial scale plays an important role in determining the possible ecological effects (Szilassi et al., 2017). The impact is in most cases negative leading to trade-offs between some ecosystem services (Nelson et al., 2010; Pereira et al., 2012).

The needs of human society affect the status of an ecosystem service as well, so that it is not only the provision, but also the needs of the society and the desired level of provision which influence the status of an ecosystem service (Paetzold et al., 2010). A certain kind of supply and demand system exists here as indicated by Paetzold et al. (2010).

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Burkhard et al. (2012) point to the necessity of a clear distinction between ecosystem functions, services and benefits.

Ecosystem services are "the benefits people obtain from ecosystems." (Millennium Ecosystem Assessment, 2005). They contribute to our well-being and economic wealth. Various aspects of ecosystem services were dealt with in recent publications and the number of publications on ecosystem services has been increasing exponentially (Báldi, 2011).

It is important to underline that the supply and demand for ecosystem services varies geographically. Sustainability objectives can be improved by accurate methods of quantifying ecosystem services (McKenzie et al., 2011). The concept of ecosystem services dates back to the 1960s. King (1966) reports about six values associated with wildlife: commercial, recreational, biological, aesthetic, scientific and social values, mentioned by Martin-Ortega et al. (2015). The monetisation of values, *i.e.* recognizable benefits from wildlife and their incorporation into cost-benefit analysis was proposed by Helliwell in 1969. The well-known publication of Constanza et al. (1997) describes the concept of ecosystem services and natural capital. The idea of expressing the value of natural values in money was criticized by several authors. *E.g.* Bastian (2016) writes about the promotion of commodification of nature, the multi-layered relationship between man and nature might be reduced to economic issues. The concept of ecosystem accounting is presented by Boyd and Banzhaf (2007).

An important milestone was the foundation of an international platform, *i.e.* the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) which is an intergovernmental body assessing the state of biodiversity and of the ecosystem services. IPBES is placed under the auspices of four United Nations entities: UNEP, UNESCO, FAO and UNDP and administered by UNEP. Its secretariat is hosted by the German government and located on the UN campus, in Bonn, Germany (http://www.ipbes.net). The present assessment of IBES was preceded by the Millennium Ecosystem Assessment (Millennium Ecosystem Assessment, 2005).

Ecosystem services can be divided in four groups (Table 1), *i.e.* supporting, provisioning, regulating and cultural. (1) Supporting services provide the basic conditions for life (*e.g.* fertile soils, nutrient cycling, primary production). 30–50 % of primary production is consumed by humans, mainly by agriculture and forestry and the rate is growing (Foley et al. 2005). (2) Regulating cervices provide the functioning of ecosystems (*e.g.* clean air, flood and decease control, pollination). (3) Supporting services belong to the third group (*e.g.* food, fuel, wood) and (4) the cultural services include *e.g.* recreational, cultural benefits.

According to Seppelt et al. (2012), Wallace (2007) the above definition by the Millennium Ecosystem Assessment (2005) and the four categories are not always appropriate and a clear distinction between ecosystem services, functions and benefits is a significant problem (Burkhard et al. 2012, de Groot et al. 2010).

Land degradation is a major threat to all ecosystem services (Kertész, 2017). The world “degradation” refers to a change to a lower quality. This is also true for ecosystem services: “Land degradation is the reduction in the capacity of the land to provide ecosystem goods and services and assure its functions over a period of time for the beneficiaries of these” (Woodfine, 2013). Crosson (1997) reports on an accelerating rate of degradation (0.4%) for the coming 30 years, accompanied by a decline of altogether 17% of agricultural activity. Land degradation has a negative effect on productivity, too. *E.g.* soil erosion causes 15–30% less production (Pimentel et al., 1993; Pimentel, 1997).

As shown above, there are different views concerning the definition of ecosystem services and the four groups of them, supply and demand at a given level of the society should also be taken into account. The most exact way to deal with ecosystem services is the expression of any service in quantitative terms. In the present paper this method will be applied.

The various methods applied for ecosystem services mapping and assessment including quantitative methods are described by Burkhard et al. (2009). There are not many publications, however, investigating the temporal changes of spatial distribution and variability of ecosystem services. An interesting and remarkable study by Smiraglia et al. (2016) investigates the linkages between land use change, land degradation processes and ecosystem services. In the authors’ opinion detailed research is needed on the temporal changes of spatial distribution and variability of ecosystem services and on the quantification of ecosystem services. The explicit modelling of agroecosystem services is an important requirement for the implementation of the concept of this services in decision-making (Makovníková et al., 2017).

Table 1
Ecosystem services provided by the land cover types (Ar: Arable, F: Forest, M: Meadow, Aq: Aquatic, W: Wetland, S: Settlement).

Ecosystem service categories	Ecosystem services	Land cover types
Supporting	Soil formation	Ar, F, M
	Nutrient cycling	Ar, F, M, Aq, W
	Primary production (biomass)	Ar, F, M, Aq, W
Regulating	Water quality	F, M, Aq, W
	Air quality maintenance	F, M, Aq
	Biological pest control	F, M
	Climate regulation	Ar, F, M, Aq, W
	Water regulation	Ar, F, M, Aq, W
	Erosion control	Ar, F, M, W
	Pollination	Ar, F, M
Provisioning	Production of food	Ar, F, M, Aq, W
	Fiber	Ar, F, M
	Fresh water	Aq, W
	Fuel (energy sources)	Ar, F
	Genetic resources	Ar, F, M, Aq, W
	Biochemicals, natural medicines, and pharmaceuticals	F, M, Aq, W
	Ornamental resources	F, M, Aq, W
Cultural	Recreation and ecotourism	Ar, F, M, Aq, W, S
	Spiritual values	Ar, F, M, Aq, W, S
	Cultural diversity	Ar, F, M, Aq, W, S
	Knowledge systems	Ar, F, M, Aq, W, S
	Educational values	Ar, F, M, Aq, W, S
	Inspiration	Ar, F, M, Aq, W, S
	Aesthetic values	Ar, F, M, Aq, W, S
	Social relations	Ar, F, M, Aq, W, S
	Sense of place	Ar, F, M, Aq, W, S
	Cultural heritage values	Ar, F, M, Aq, W, S

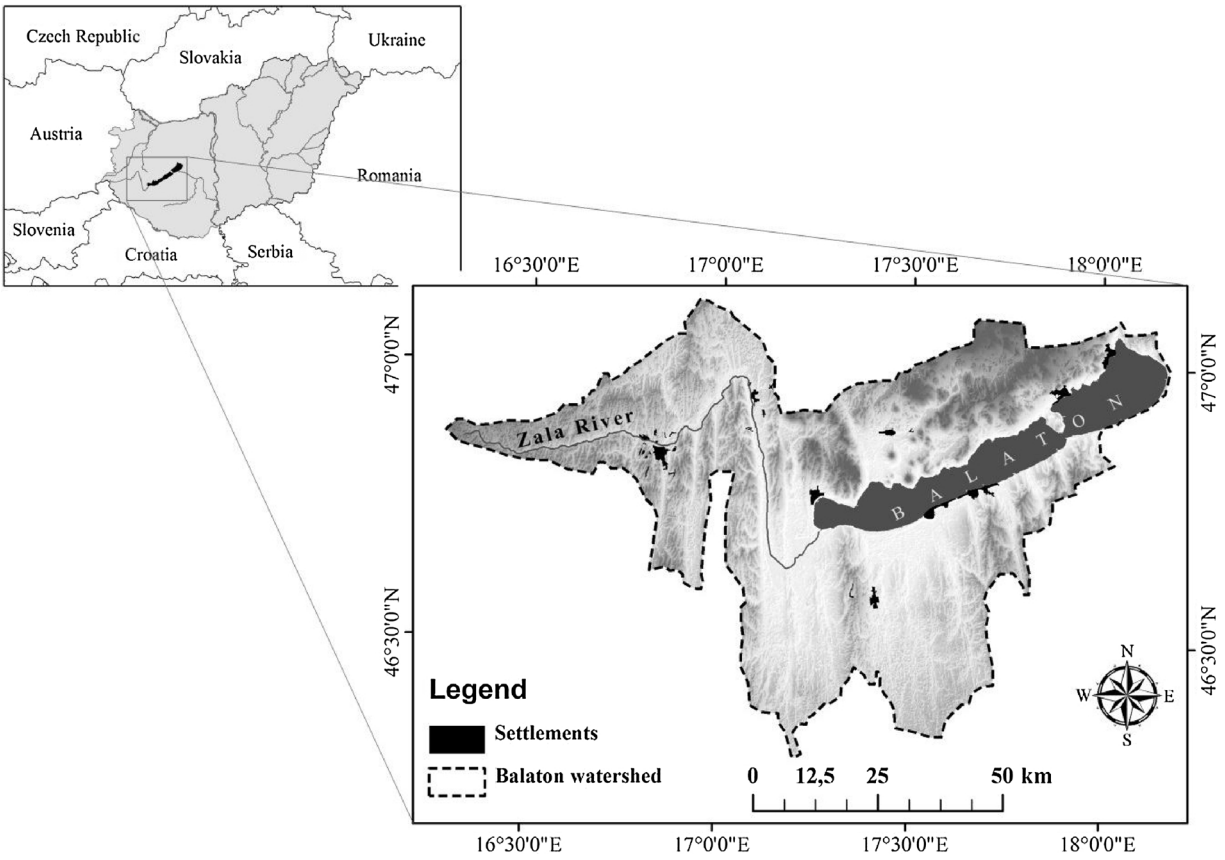

Fig. 1. Location of the study area.

Table 2
Summary of the applied database.

Database	Derivates	Downloaded from
EU-DEM	aspect, slope	https://www.eea.europa.eu/data-and-maps/data/copernicus-land-monitoring-service-eu-dem
MOD13Q1 NDVI	NDVI (yearly average) 2000 (20 pcs); 2006 (23 pcs); 2012 (23 pcs)	https://earthexplorer.usgs.gov/
OSM roads	roads	http://www.openstreetmap.hu/
Hungarian Hiking Trails	hiking trails	http://turistautak.hu
Topographic Map of Hungary	boundary of Lake Balaton	
CLC (1990; 2000; 2006; 2012)	forest, water	https://land.copernicus.eu/pan-european/corine-land-cover/clc-2000?tab=download
Nature Conservation Information System	Protected areas of national importance, Natura 2000 sites	http://geo.kvvm.hu/tir_en/viewer.htm
Nation Information System of Regional Development and Spatial Planning	number of tourist accommodations, number of catering services	https://www.teir.hu/

In many cases no data are available to carry out a monetary analysis of an ES, therefore an alternative method will be suggested and applied in this paper, which is also applicable for supporting land use policy and to provide a basis for decision making on land use issues.

The objective of the present paper is to apply the Multi-Criteria Evaluation method (MCE) to estimate the value of the ES of recreation and ecotourism and for the investigation of the changes of this ES between 2000–2012. A further aim is to investigate the areal changes of land use categories (1990–2012). Lake Balaton catchment was selected to present the method. The area is a frequented touristic region of Hungary disposing of a great variety of landscape elements where ES related to water, vegetation and topography can be found.

2. Material and methods

2.1. Study area

Lake Balaton, which is the largest freshwater lake in Central Europe is situated in western Hungary. (Fig. 1) It is the biggest lake in Central Europe (595 km^2) collecting water from an extensive catchment (5.705 km^2), the average depth is 3.25 m (Polyák and Hlavay, 2005). The longitudinal extent is about 80 km, the water capacity is about 2 km^3 (Tullner and Cserny, 2003). The slight depth and the warm water make the lake attractive for tourism but the low depth makes it ecologically sensitive to pollution (Puckzó and Rátz, 2000). The lake and its catchment are exposed to various kinds of environmental impacts including agricultural activities. The influx of sediment and solutes flowing into the lake deriving mainly from non-point pollution sources plays and important role from the aspects of the eutrophication and

Table 3
Criteria of Multi-Criteria Evaluation of Recreation and Ecotourism ES.

Constraints	
Name	
Forest	2000, 2006, 2012
Water	2000, 2006, 2012
Protected areas of national importance	
Natura 2000 sites	
Number of tourist accommodations	2000, 2006, 2012
Number of catering services	2000, 2006, 2012
Factors	
Name	*Fuzzy membership function*
Aspect	Sigmoidal, symmetric
Slope	Sigmoidal, monotonically decreasing
NDVI	Sigmoidal, monotonically increasing
Distance from roads	Linear, monotonically decreasing
Distance from hiking trails	Linear, monotonically decreasing
Distance from Lake Balaton	Linear, monotonically decreasing

Table 4
Land use changes in Lake Balaton Catchment 1990–2012 (CORINE Land Cover).

Land use	1990		2000		2006		2012		Changes in area 1990–2012	
	km^2	%	km^2	%	km^2	%	km^2	%	km^2	%
Artificial surfaces	322.0	5.6	282.2	4.9	305.4	5.4	312.2	5.5	−9.8	−0.2
Arable land	2016.8	35.3	2087.5	36.6	2079.8	36.5	2063.3	36.2	**46.6**	**0.8**
Vineyards	224.4	3.9	215.9	3.8	214.6	3.8	190.6	3.3	−33.8	−0.6
Fruit trees	32.9	0.6	33.1	0.6	33.8	0.6	27.3	0.5	−5.5	−0.1
Pastures	267.0	4.7	392.2	6.9	375.3	6.6	383.0	6.7	**116.0**	**2.0**
Forest	1769.4	31.0	1783.0	31.2	1802.0	31.6	1835.5	32.2	**66.1**	**1.2**
Natural grasslands	271.1	4.8	102.2	1.8	104.9	1.8	103.7	1.8	−167.5	−2.9
Wetlands	168.1	2.9	177.8	3.1	155.2	2.7	153.8	2.7	−14.3	−0.3
Water bodies	633.8	11.1	631.6	11.1	634.6	11.1	636.0	11.1	**2.2**	**0.0**
	100%		100%		100%		100%			

pollution of the lake (Szilassi et al. 2006; Van Dessel et al. 2008). The southern shoreline is a sandy beach, the northern subcatchment consists of hills and mountains of volcanic origin, landscape mosaics of vineyards, forests, arable fields make the area very attractive for visitors (Rátz, 2003). The impact of tourism and recreation is very significant in the all catchment.

2.2. Data set

The extent of the different land use categories has a great impact on the spatial distribution of ecosystem services, especially on recreation and ecotourism. In this case the spatial pattern of natural, semi-natural vegetation and the waterbodies are relevant. The CORINE Land Cover database (CLC) is a commonly used data base for the analysis of ecosystem services. The input layers were selected from CLC (2000, 2006, 2012). The methodology of LC mapping is standardized for the EU countries. The map scale is 1:100.000 and the minimum mapping unit is 25 ha (EEA, 2002).

The CLC database was applied as the basis of land use change analysis between 1990 and 2012, presented in this paper.

Recreation and ecotourism are highly affected by the extent of surface vegetation which can be identified by the commonly used Normalized Difference Vegetation Index (NDVI, Rouse et al. 1974). We used the MOD13Q1 NDVI product, downloaded from the USGS Earth Explorer website. The NDVI is calculated from the red (620–670 nm) and the near infra-red (841–876 nm) spectral bands, both have a spatial resolution of 250 m. The 16-day composites have gridded level-3 data (Solano et al., 2010). We downloaded 20, 23 and 23 images from the years of 2000, 2006 and 2012 respectively, in order to calculate the yearly average NDVI values.

The protected areas could be potential targets of recreation and ecotourism. National parks, landscape protection areas, nature conservation areas, natural monuments, Natura 2000 sites were analysed by the MCE method. The database was downloaded from Nature Conservation Information System online interface (http://geo.kvvm.hu/tir_en/viewer.htm).

Aspect and slope are essential spatial variables and suitable tools for the characterization of environmental variability. They were derived from the EU-DEM database. EU-DEM is a collaboration project of the member countries of the European Environment Agency, coordinated by the Copernicus Programme. The result is a hybrid product based on data fusion of SRTM and ASTER GDEM, elaborated by the weighted averaging approach. The basic concept of this project was to accomplish an automatic data fusion of the two DSM then improve it by adding new hydrography datasets and partly the NEXTMap data (Bashfield and Keim, 2011). The dataset is a 3D raster covering the European Union with elevations captured at 1 arc second postings corresponding to an approximately 25 m geographic accuracy (Józsa and Kalmár, 2014). The complete dataset is available as 1000 × 1000 km (5° × 5°) tiles or in as one dataset with the EPSG:3035 coordinate system, from the EEA website (https://www.eea.europa.eu/data-and-maps/data/copernicus-land-monitoring-service-eu-dem). It was disclosed that the dataset has minor horizontal misfits but still provides a better applicability then the SRTM and ASTER GDEM (Józsa et al., 2014).

The accessibility and connectivity of high priority areas and landscape patches like forests and water bodies depend on the network of the built road network and hiking trails. The spatial distribution and

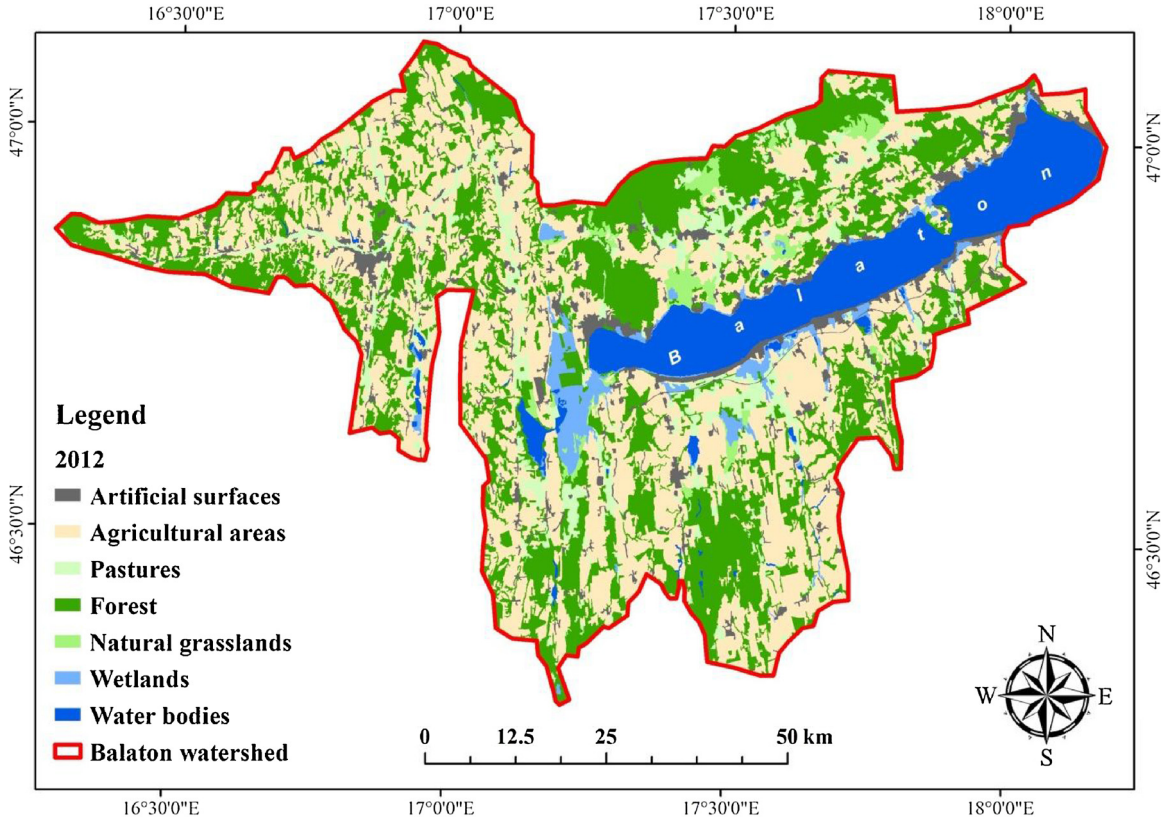

Fig. 2. Land use types of Lake Balaton Catchment in 2012 (based on the CORINE Land Cover Database).

density of hiking trails are outstanding in Europe, thus the expansion, realignment, multifunctional development and maintenance of these hiking trails contribute an increasing potential of ecosystem services (Kozics et al., 2015). The distance from roads and hiking trails was calculated on the basis of the OSM (OpenStreetMap database), and of the Hungarian Hiking Trail online database. The distance values from Lake Balaton were also determined.

The capacity for tourism can be characterized by the number of accommodations and catering services. These data were downloaded from the interface of the National Information System of Regional Development and Spatial Planning for the years of 2000; 2006; 2012, respectively.

The input data are presented in Table 2.

2.3. Evaluation of ecosystem services

One of the most important applications of GIS methods is to improve the visualization and analysis of spatial data and they support thereby the decision-making process. Decisions are based on more criteria or criteria-sets, *i.e.* on the variation and combination of measurable factors. These factors or criteria can be geographic or statistical data. The MCE method (Voogd, 1982) is suitable to aggregate numerous criteria. Two types of criterion could be determined: Boolean (true/false) constraints and factors (continuous) criteria (Eastman, 1999). According to Boolean statements of suitability the area should be omitted then these criteria can be combined with some further logical operations. The suitability of the criterion can be described by continuous variables in a more sophisticated way. The factors must be standardized to a special numeric scale (*e.g.* 0–1, 0–100 or 0–255). As the result of standardization the factors will show the suitable and unsuitable (relevant and irrelevant) pixels on a continuous scale. As a next step, the criteria (both constraints and factors) can be combined by Weighted Linear Combination (WLC). First the factors will be multiplied by their weight then the result will be intersected by the Boolean constraints (Eastman 2012).

In this paper a MCE method was applied in order to quantify the RE ES (Recreation and Ecotourism Ecosystem Service) value on 0–255 scale. The analysis was performed with a 500*500 m spatial resolution, fitting to the scale of the input data and suitable for demonstrating the spatial distribution of the investigated ecosystem service. Values of all criteria were extracted by the 500*500 m resolution grid. Table 3 presents all criteria used for MCE.

For the implementation of the MCE process both types of criteria related to RE ES were prepared. The discrete properties were the selected categories of land use (forest, water), the protected areas, the Natura 2000 sites and the statistical parameters of tourism (number of accommodations and catering services).

The forests and the open water bodies were derived from the CLC database and the categories were simplified. *E.g.* all forest types were merged into one category.

The layer of protected areas containing the national parks, the landscape protection areas, the nature conservation areas and the natural monuments was converted to a Boolean image as well as the Natura 2000 sites.

Settlement boundary polygons were applied as a basis for assigning the number of accommodations and catering services. The values were extracted by the processing grid and transformed into binary raster datasets.

Six continuous geographic data were used as factors of the MCE method: aspect, slope, NDVI, distance from roads, from hiking trails and from Lake Balaton. Aspect and slope were derived from EU-DEM database and the mean value was extracted by the processing grid. The input raster datasets were rescaled from 0 to 255 with fuzzy tool. The selection of membership function depends on the relationship between the criterion and the decision set (Jiang and Eastman, 2000). In most cases, either the sigmoidal or the linear functions are sufficient.

In the case of aspect the sigmoidal, symmetric membership function was applied to set the South-oriented slopes as the most suitable. For

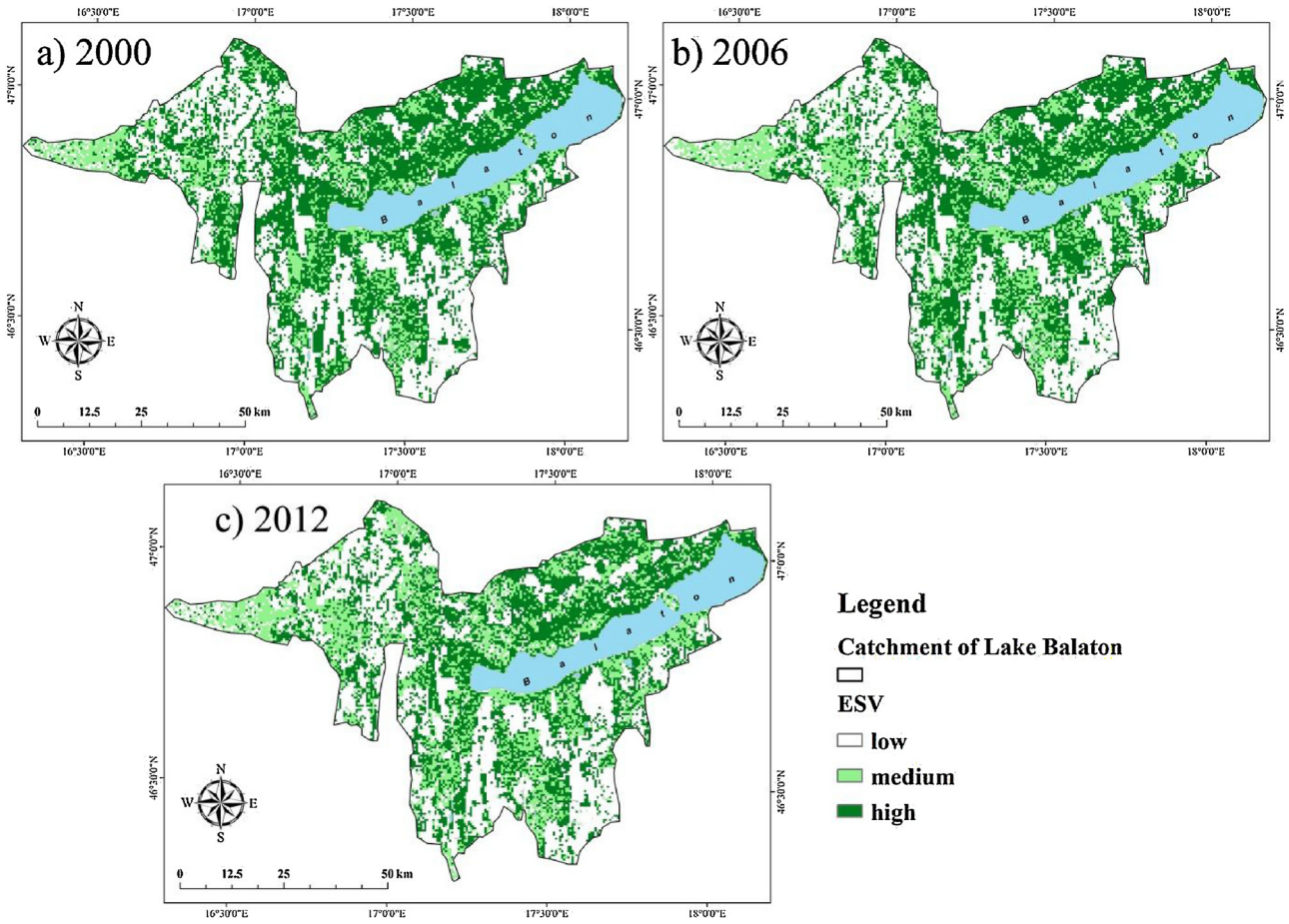

Fig. 3. Spatial distribution of ESV in Lake Balaton Catchment (a: 2000, b: 2006, c: 2012).

Table 5
The percentage of ESV categories.

	2000	2006	2012
Low ESV	2.7%	4.1%	6.0%
Medium ESV	38.8%	42.3%	46.4%
High ESV	58.5%	53.6%	47.6%
	100.0%	100.0%	100.0%

the slopes also sigmoidal, but monotonically decreasing membership function was selected in order to ensure that the steeper slope is the less relevant for the analysis.

The NDVI was calculated from the MODIS image sets by extracting the mean values to the processing grid cells. From the aspect of RE ES the higher NDVI value is the better and has more impact on ESV; thus, the sigmoidal, monotonically increased membership setting was applied for standardization. In the case of the distance layers the higher distance values are less relevant from the aspect of RE ES.All preparation processes were conducted in ArcGIS 10.3, the MCE method was implemented in IDRISI Selva.

3. Results

3.1. Changes in land use

Land use changes between 1990–2012 are shown in Table 4. More than two thirds of the total catchment area was occupied by arable land and forest during the whole investigation period. Pastures show the greatest land cover increase both in area and in percentage, followed by forest and arable land. The largest decrease in area (−2.9%) was detected in the case of natural grassland. Among the nine land use type categories continuous increase of the forest area has been increasing moderately, but continuously. The land use map of Lake Balaton Catchment in 2012 is presented in Fig. 2. There was relatively small decrease in the case of vineyards and the area of wetlands is slightly fluctuating between 1990–2012.

3.2. Changes of recreation and ecotourism ES values

The RE ESV was calculated for each study year (2000, 2006, and 2012) and visualized on maps (Fig. 3). The ESV was divided into 3 categories: areas with low, medium and high ESV. The spatial pattern of values shows the diversity of the study site. The higher ES values concentrate along the shoreline of Lake Balaton and in the hilly and mountainous areas of northern catchment. The areas with lower ESV are located in the southern and north-western part of the catchment, where agricultural land use is dominant. Whereas arable lands cover more than one third of the study area, the area of low ESV occupy only 2.7%; 4.1%; 6%, respectively (Table 5). The extent of medium ESV slightly increased between 2000 and 2012, from 38.8% to 46.4%. The percentage of high ESV decreased continuously from 58.5% to 47.6%.

4. Discussion

Land use changes between 1990 and 2012 were investigated in this paper. The year 1990 was chosen as the starting point of the analysis because of the change of the regime took place in 1989 and so the year after still showed the land use structure of the old regime. The change of the regime made a significant influence on land use structure, first of all as a result of reprivatisation. The changes between 1891–2001 were

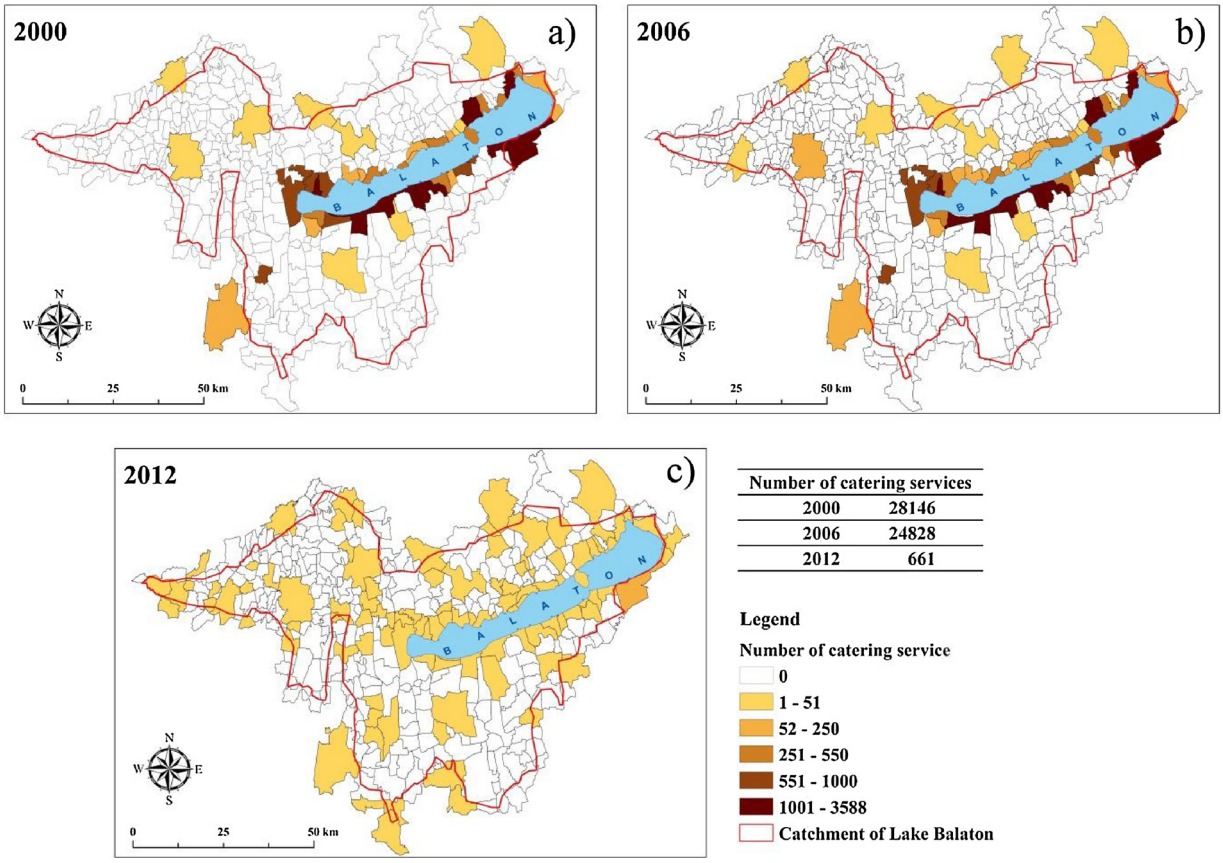

Fig. 4. Spatial distribution of catering services (a: 2000, b: 2006, c: 2012).

dealt with by Kertész (2012). No significant changes happened between the World War I and II, *i.e.* the percentage of forests and arable land changed just a little. The important changes started after 1950 when the agricultural area began to diminish. The percentage of arable land was 40–45 % between 1895–1950 followed by a significant decrease (40% in 1984 and only 35.3% in 1990).

The percentage of forests was approximatively 25% between 1895–1950, and it reached only 25.6% in 1984 (Szilassi et al., 2006) increasing continuously and reaching 31% in 1990 and 32.2% in 2012. Comparing global land use structure with that of the catchment the following statements can bemade. The largest terrestrial biomes of the planet are croplands and pasture occupying roughly 40% of land surface (Foley et al. 2005). According to World Bank data (2018) the extension of agricultural land was 37.2% in 2015. Agricultural land in the catchment diminished to 40.0% in 2012 (Table 4), the share of pasture was 6.7%. These numbers are not significantly different from world data. The trends are, however, not the same. In the world the area of cropland has been increasing by 12%. The increase of agricultural area in the world is a positive phenomenon from the aspect of food supply, however, agricultural activities increase soil erosion risk, as mentioned before. The share of the forest area in the catchment (32.2% in 2012) is slightly bigger than the world average (30.9 in 2012, The world Bank, 2018) and much more significant that the forest area of the whole country (22.1% in 2012, KSH, 2013).

Considering the relationship between the area represented by each land use category and their share in all ecosystem services the following statements can be made (based on the calulations of Dombi, 2012). The total territory of lakes and rivers is insignificant (only 2%) in Hungary, however, they provide approximately one third of the ecosystem services. Food supply represents 10.7% of all ecosystem services referring to the importance of agricultural areas. In 2011 the total value of ecosystem services in Hungary was $1640{,}18 \times 10^{10}$ HUF (Hungarian Forint, corresponding roughly to 58744 €, Dombi 2012).

The ESV of the study area was calculated for 3 years, 2000, 2006 and 2012. The decreasing tendency of ESV can be explained by the decrease of the number of catering services in the area (Fig. 4). Differences in the spatial distribution of catering services can be identified on the map shown in Fig. 4.

In this paper, like in several other studies (Haase et al. 2014; Lu et al. 2014) measurable, quantitative variables were applied (see Table 3), however, the method has uncertainty as well. The main limitation of the ES mapping is that it relies on proxies (*e.g.* spatial, demographical and economic data) with potentially large errors (Eigenbrod et al. 2010). Despite of these limitations a better improvement could be achieved than using only land cover database, as applied in some researches relating to recreation ES (Chan et al. 2006; Sutton and Costanza 2002; Troy and Wilson 2006). The development and validation of ESV calculation methods could be reached through interviews, questionnaires, surveys (Brown and Fagerholm 2015) or stakeholder-based approaches (García-Nieto et al. 2015).

5. Conclusion

In this paper a GIS-based approach, the MCE method was applied to calculate and visualize the spatial pattern of ESV at regional level. Recreation and ecotourism services were evaluated by the MCE method. Other ecosystem services could also be estimated by MCE, setting up different criteria according to the service to be analysed, *e.g.* food production, which can be a possible input of an integrated hydrological model, too (Kozma et al. 2012).

The MCE method as a non-monetary approach can be applied for the comparison of different regions as the influencing factors are expressed as standardized values and not as real monetary values, thus, for example the inflation rate is not confounding the interpretation.

Ecosystem services are usually evaluated as benefits for human society. It should be emphasised, however, that they are also important for nature, *i.e.* for the functioning of the landscape.

Policy making should concentrate on the continuous management of land use changes and on ecosystem services maintenance and improvement, *i.e.* on the support of soil conservation measures, on the control of farm management etc.

Land use and land cover changes also affect regional climates (Foley et al., 2005). The latter statement should be kept in mind by policy makers also in Lake Balaton catchment.

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